

Article

Changes in Body Mass and Movement Strategy Maintain Jump Height Immediately after Soccer Match

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Abstract: A countermovement jump (CMJ) performed on a force plate is commonly applied in soccer to quantify acute neuromuscular fatigue (NMF), which may manifest immediately following soccer match play. Jump height (JH) is the main outcome variable reported for this purpose; however, it is sensitive to alterations in movement strategy, which may act to mask JH and, therefore, mask any presence of NMF. Acute reductions in body mass (BM) during match play could also lead to the maintenance of JH, but this is yet to be explored. This study sought to explore soccer-match-induced alterations to JH, movement strategy, and BM to inform future variable selection for the study of acute NMF. Fourteen male English National League soccer players performed three CMJs on a dual-force plate system immediately before and after a competitive soccer match. Differences in jump height were non-significant and trivial ($p = 0.924$, $g = 0.03$) before and after soccer match play, but there was a large post-match decrease in BM ($g = 1.66$). Furthermore, moderate decreases in jump momentum ($g = 0.56$) and countermovement depth ($g = 0.72$) were noted. As JH was determined by the take-off velocity, reduced BM could have augmented it (less mass to accelerate); however, reduced countermovement depth seemingly counteracted this (less distance to attain velocity). It may, therefore, be beneficial to report these variables when monitoring acute NMF via the CMJ.

Keywords: neuromuscular fatigue; countermovement jump; force plate; force platform; football



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1. Introduction

In professional soccer, half of surveyed strength and conditioning coaches report the regular use of force plates for the assessment of neuromuscular capabilities [1]. The rise in force plate assessments across the football codes is likely to continue as more commercially available and affordable force plate systems are validated against both industry gold-standard force plates [2,3] and criterion data analysis procedures [4]. One application of force plate testing in professional sports is to monitor acute neuromuscular fatigue (NMF) [5]. Although several definitions of NMF have been proposed, it can be broadly defined as an exercise-induced reduction in (1) maximal voluntary force generation [6] and (2) the control of submaximal force production [7] by a single muscle or several muscle groups. In soccer, acute NMF has been shown to reduce kicking accuracy and increase the time required to perform a kicking task [8], in addition to increasing injury risk, particularly during periods of soccer fixture congestion [9]. Such congestion is characteristic of the modern soccer game, with players regularly, and for a large part of the calendar year, exposed to competitive match-play environments. Therefore, studies concerned with the assessment of acute fatigue are of considerable value.

The bilateral countermovement jump (CMJ) is the most common test of lower-body neuromuscular readiness (i.e., recovery from NMF) in peer-reviewed studies involving athletes from the football codes, including soccer [10]. However, the application of force plate assessments of the CMJ in the context of monitoring acute NMF within the soccer literature is limited. Force plate assessments of either the bilateral or unilateral variation

in the CMJ have been explored in academy males [11–13], collegiate females [14], and elite females [15] to explore the acute effects of soccer match play on NMF but with inconsistent methodological designs employed, most notably, distinctions in the CMJ variables presented for analysis, the timing of the post-match CMJ assessment(s), and the sample sizes. Consequently, the collective results from these studies have been largely equivocal, although some similar patterns can be identified. For example, a significant difference in bilateral CMJ height was observed in one study, with higher values before versus immediately after a soccer match [15], but this outcome was not reinforced [11] or evident for the unilateral CMJ height performance [12]. The post-soccer-match bilateral CMJ height was significantly lower than the pre-soccer-match values at two discrete time points (5 and 21 h post-match) in the study by Anderson et al. [15]. This was similar to the findings of a more recent study, with a lower post-soccer-match CMJ height reported 12 h post-match [14]. In this study, the post-match testing was not immediate (e.g., 12 h afterwards only). Interestingly, the reduced jump height values within the 24 h post-match period were reported only in the studies involving female soccer players [14,15].

Despite the similar post-soccer-match unilateral CMJ height values, Bromley et al. [12] reported a reduction in the propulsive net impulse immediately after a soccer match (for both legs) and 24 h later (left leg only). A reduced propulsive net impulse should coincide with a reduced jump height when using the impulse-momentum method to calculate the latter [16], which the authors did, unless the players' body mass had reduced to counteract this. Thus, it may be deduced that the mean body mass had acutely reduced as a consequence of soccer match play. Acute reductions in body mass of ~2% can be expected in response to soccer match play, and this can be attributed to dehydration and glycogen depletion [17]. Being acutely lighter should, theoretically, facilitate greater jump height attainment in the absence of NMF if the same propulsive net impulse is applied based on the jump height being governed by the take-off velocity, which in turn is governed by the propulsive net impulse relative to body mass [16].

In addition, Bromley et al. [12] and Ishida et al. [14] reported a reduction in the braking net impulse during the hours immediately following a soccer match. A reduction in the braking net impulse would occur when there is a reduction in the peak velocity (negative direction) during the preceding unweighting phase. This is the first phase of movement during the CMJ, in which one relaxes the leg extensor musculature to commence hip, knee, and ankle flexion under a constant gravitational acceleration [18]. A reduction in the peak unweighting velocity would mostly be due, therefore, to a reduction in unweighting displacement and, thus, countermovement depth, which reflects the peak (negative direction) center mass displacement between the onset of movement and the end of braking. Unfortunately, Bromley et al. (2021) and Ishida et al. (2021) did not report countermovement depth in their studies. However, countermovement depth showed the largest change (~8%) immediately post-match among the bilateral CMJ variables reported by Thorlund et al. [11]. A recent study in which bilateral CMJ performances were monitored across several microcycles highlighted the association between the countermovement depth and braking net impulse, which were both reduced by the largest magnitude three days prior to a soccer match fixture [13]. Interestingly, the jump height variables remained relatively unchanged across the weekly microcycle, with pronounced changes observed mainly in the countermovement phase (combined unweighting and braking) of the CMJ [13]. A shallower countermovement depth would lead to reduced propulsive displacement, limiting the take-off velocity by constraining the distance available to propel the body's center of mass and, thus, the mechanical work performed during propulsion.

The limited studies mentioned above show that jump height may or may not acutely reduce immediately after a soccer match and that this may be due to concomitant changes in body mass and/or movement strategy (e.g., countermovement depth) during the CMJ. This may mask the presence of NMF if jump height is solely reported. The purpose of this study was, therefore, to monitor soccer-match-induced changes in body mass alongside select CMJ movement strategy and outcome variables among adult male soccer players. It

was hypothesized that both body mass and countermovement depth would be reduced post-match but jump height would remain unchanged. This study will help to inform soccer researchers and practitioners about alternate CMJ variables pertaining to movement strategy that may be more sensitive for detecting the presence of acute NMF than jump height alone.

2. Materials and Methods

2.1. Participants

The average effect size point estimate for changes in CMJ force–time variables in response to soccer match play is 0.8 [14]. Therefore, to explore the difference between two dependent means with an expected average effect size of 0.8, a statistical power of 80%, and an a priori alpha level of ≤ 0.05 , the required sample size ranged from twelve (one-tailed) to fifteen (two-tailed) participants. In this study, fourteen adult male footballers from a squad within the National League division of English soccer participated (age: 26.6 ± 4.4 years; height: 1.81 ± 0.05 m; body mass: 79.8 ± 6.6 kg). The English National League is the fifth-highest division overall in English men's soccer, which at the time of testing, included both professional (full-time) and semi-professional (part-time) soccer clubs; therefore, the athletes included in this study may be classified as tier 3 (i.e., highly trained/national-level) participants [19]. The participants consisted of defenders ($n = 6$), midfielders ($n = 5$), and strikers ($n = 3$). The institutional ethics committee approved the study (reference number: HST1920-332), and it was conducted in concordance with the Declaration of Helsinki. All participants were informed of the risks and benefits before completing an institutionally approved physical activity readiness questionnaire and a consent form to participate in the study. The players were tested during the early in-season period after just the fourth competitive game of the 2020–2021 soccer season.

2.2. Protocol

An experimental approach with a repeated-measures design was employed. On identified match days against an opponent in a similar position within the league table, a minimum of four participants were tested before and after a soccer match on each occasion until all fourteen participants were tested. Pre-soccer testing took place approximately ninety minutes before the home weekend fixture (testing at 13:30 with kick-off at 15:00). Post-match testing took place immediately after the game, at approximately 17:00 (within 15 min after the soccer match had been completed). If testing was conducted on the day of a Tuesday fixture, participants were tested at 18:30 (kick-off at 20:00) and post-tests were conducted at 21:45, directly after the game. The participants played at least the first sixty-five minutes of the game time to be eligible for inclusion. Familiarization sessions were completed during training sessions before starting the study to minimize learning effects. The force plates were set up in the team dressing room on a solid vinyl-lined floor. All players performed their jumps wearing the team kit or a pre-match warm-up kit and their own running trainers. Players who were substituted were taken in for testing within 15 min of leaving the pitch. None of the players who completed either the full match or a partial match sustained any injuries during the match.

All participants completed a standardized dynamic warm-up lasting ten minutes prior to data collection. The warm-up consisted of jogging, dynamic mobility, and the activation of the lower-body musculature, followed by two practice CMJs at 50% and 75% effort. The participants then performed three recorded maximal-effort CMJs to their self-selected countermovement depth. Each CMJ trial was interspersed by ~ 30 s of rest. The participants were asked to “jump as fast and as high as possible” whilst keeping their hands on their hips throughout the CMJ. If any participant did not keep their hands on their hips throughout the CMJ, they repeated the trial until three acceptable trials were achieved (no more than five CMJ trials were performed by any participant).

2.3. Data Collection

Each participant's standing height was measured using a stadiometer, and their body mass was determined from the force plate data (see Section 2.4).

The vertical ground reaction force (GRF) data during the maximal-effort CMJs were recorded at 1000 Hz via a wireless dual-force plate system and the associated proprietary software (Hawkin Dynamics (HD) Inc., Westbrook, ME, USA), which was validated against a criterion force plate system [20]. The force plates were zeroed before each CMJ trial. The proprietary HD software was operated via an android tablet that connected with the system via Bluetooth. The raw GRFs were automatically filtered with a low-pass 50 Hz cut-off frequency [21]. After each trial, data were instantaneously exported via Wi-Fi to the Hawkin Dynamics cloud server, and they were later downloaded for data management in Microsoft Excel.

The Playertek global positioning system (GPS, Catapult Sports, Melbourne, Australia) operating at 10 Hz monitored the match activity data, including the total distance, sprint distance, total and sprint distance per minute, number of sprints, top speed (kph), and power plays (number of accelerations or high-speed actions involving a power output of $>20 \text{ W}\cdot\text{kg}^{-1}$) during games, which are presented for descriptive purposes. The GPS units were positioned on the upper back by placing them inside vests worn by the participants. All GPS settings, such as speed thresholds, were set as per the propriety software provider.

2.4. Data Analysis

Within the Hawkin Dynamics software, the net force was calculated by subtracting the body weight from every force sample. The body weight was determined as the mean force over the first 1 s of the recorded CMJ trials while the participants were standing still and upright. The body mass was calculated by dividing the body weight by the gravitational acceleration (9.81 m/s^2). The center of mass velocity was then calculated by dividing the net force by the body mass for each sample and then integrating the product using the trapezoid rule [22]. The instantaneous center of mass displacement was calculated by integrating the velocity data for each sample, also using the trapezoid rule [22]. The onset of movement was identified in line with the criterion recommendation [23]. The instant of take-off was identified when the force fell below 25 N. The countermovement phase comprises both the unweighting and braking phases and was identified between the onset of movement and zero velocity, and the propulsion phase was identified when the vertical velocity became positive and finished at take-off [24].

The time to take-off was calculated as the time period between the onset of movement and take-off. Moreover, the individual times of the unweighting, braking, and propulsive phases were calculated to highlight where any potential changes in the time to take-off arose. The countermovement depth was calculated as the peak negative value of center of mass displacement prior to take-off. The jump height was derived from the vertical velocity of the center of mass at take-off [22]. The jump momentum was calculated by multiplying the vertical velocity of the center of mass at take-off by the body mass [25]. The modified reactive strength index (RSI_{mod}) was also calculated by dividing the jump height by the time to take-off.

2.5. Statistical Analysis

Three CMJ trials were completed, with the average used for all within-group comparisons. The Shapiro–Wilk test was applied to assess the data distribution. For parametric dependent variables (body mass, jump height, jump momentum, time to take-off, unweighting phase time, braking time, propulsive time, RSI_{mod}, and CM depth), discrete paired-sample *t*-tests were applied to examine the effect of time (before and after a soccer match). For equivalent comparisons involving non-parametric data (unweighting phase time), a Wilcoxon signed-ranks test was applied. Descriptive statistics were calculated and are presented as the mean \pm the standard deviation for all variables other than the unweighting phase time, which is presented as the median \pm the interquartile range. The

relative between-trial reliability was assessed via a two-way random-effects intraclass correlation coefficient (ICC). ICC values of <0.5, between 0.5 and 0.75, between 0.75 and 0.90, and >0.90 were classified as poor, moderate, good, and excellent relative reliability, respectively [26]. The absolute between-trial reliability of each variable was calculated using the coefficient of variation percentage (CV%), with values of $\leq 10\%$ and $\leq 5\%$ considered to represent good and excellent absolute reliability, respectively [27]. Effect sizes were calculated using the Hedges' g method, providing a measure of the magnitude of the differences noted in each variable between time points, and were interpreted as trivial (≤ 0.19), small (0.20 to 0.49), moderate (0.50 to 0.79), or large (≥ 0.80) [28]. All data were analyzed within the Statistical Package for Social Sciences (SPSS version 26.0, SPSS Inc, Chicago, IL, USA), with statistical significance accepted at $p \leq 0.05$. Significant outcomes were subsequently represented visually using Gardner–Altman plots [29] profiling individual (participant-level) responses before and after the soccer matches.

3. Results

Descriptive statistics for the match activity data (derived from GPS) are presented in Table 1.

Table 1. Recorded match activity data from the soccer players, as collected from the global positioning system (GPS).

GPS Variables	Mean	SD
Time Played (min)	83.13	11.32
Total Distance (m)	9550	1866
Sprint Distance (m)	974.27	438.47
Distance/min ($\text{m}\cdot\text{min}^{-1}$)	98.90	20.41
Top Speed ($\text{m}\cdot\text{s}^{-1}$)	8.53	0.34
Power plays (count)	71.29	21.95

Each CMJ measure presented good to excellent between-trial reliability, apart from the unweighting and braking phase times (Table 2).

Table 2. Between-trial intraclass correlation coefficients and coefficients of variation.

Jump Variables	Pre-Match ICC	Post-Match ICC	Pre-Match CV%	Post-Match CV%
Body Mass (kg)	0.99	1.00	0.15	0.13
Jump Height (m)	0.86	0.81	3.88	3.97
Jump Momentum ($\text{kg}\cdot\text{m}\cdot\text{s}^{-1}$)	0.98	0.98	1.51	1.26
Time to Take-off (s)	0.67	0.87	9.83	8.16
Unweighting Phase Time (s)	0.48	0.67	14.28	14.57
Braking Phase Time (s)	0.77	0.48	8.84	10.01
Propulsive Phase Time (s)	0.93	0.92	3.79	4.12
RSImod	0.74	0.87	9.37	8.32
CM Depth (m)	0.91	0.79	5.06	6.21

Key: ICC = intraclass correlation coefficient; CV% = coefficient of variation percentage; CM = countermovement; RSImod = modified reactive strength index.

Descriptive statistics and comparisons of pre- and post-match CMJ variables are shown in Table 3. Body mass decreased significantly during the soccer matches ($p < 0.001$), with a large effect size ($g = 1.66$).

There were also significant, moderate post-match reductions in jump momentum ($p = 0.049$, $g = 0.56$) and countermovement depth ($p = 0.016$, $g = 0.72$). No significant difference was observed for any other CMJ variable between the time points. Small post-match increases in the time to take off and the unweighting phase time were noted ($g = 0.28$ and 0.31 , respectively). However, these differences were not statistically significant. Further

small effect sizes for the propulsive time and RSI_{mod} were noted, but these were not significant and were borderline trivial ($g = 0.20$).

Table 3. Pre- and post-match countermovement jump performance of the soccer players.

Jump Variables	Pre-Match	Post-Match	Mean Difference *	<i>p</i>	<i>g</i>
Body Mass (kg)	79.8 ± 6.6	78.2 ± 6.5	1.62	<0.001 [†]	1.66
Jump Height (m)	0.38 ± 0.04	0.38 ± 0.03	<0.01	0.924	0.03
Jump Momentum (kg·m·s ⁻¹)	217.4 ± 20.2	212.7 ± 19.4	4.66	0.049 [†]	0.56
Time to Take-off (s)	0.81 ± 0.16	0.84 ± 0.19	0.03	0.303	0.28
Unweighting Phase Time (s)	0.36 ± 0.06 **	0.40 ± 0.08 **	0.01	0.091	0.31
Braking Phase Time (s)	0.17 ± 0.04	0.18 ± 0.05	<0.01	0.640	0.12
Propulsive Phase Time (s)	0.25 ± 0.05	0.25 ± 0.04	<0.01	0.459	0.20
RSI _{mod}	0.49 ± 0.10	0.47 ± 0.12	0.01	0.457	0.20
CM Depth (m)	0.32 ± 0.07	0.30 ± 0.06	0.02	0.016 [†]	0.72

Key: m = meters; s = seconds; kg = kilograms; m·s⁻¹ = meters per second; *p* = significance, set at 0.05; *g* = Hedges effect size; CM = countermovement; RSI_{mod} = modified reactive strength index. [†] denotes statistically significant difference ($p \leq 0.05$). * denotes the median difference is presented for unweighting phase time. ** Median ± interquartile range.

A visual representation of the individual changes in body mass, jump momentum, and countermovement depth is presented via the Gardner–Altman plot in Figure 1.

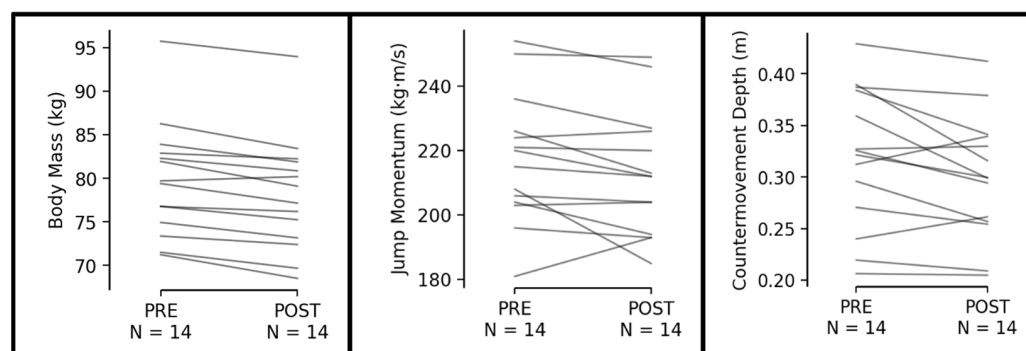


Figure 1. Individual changes in body mass (left), jump momentum (middle), and countermovement depth (right).

4. Discussion

The purpose of this study was to monitor soccer-match-induced changes in body mass alongside select CMJ strategy and outcome variables among adult male soccer players. It was hypothesized that both body mass and countermovement depth would be reduced post-match but jump height would remain unchanged. Based on the study results (Table 3), all three hypotheses were accepted.

In the present study, post-match body mass was 2% lower than pre-match, which supports previous findings [17]. Although this may be considered a small reduction in body mass, a 1.7% variability in body mass across CMJ trials resulted in a 4.5 cm deviation in the total (peak center of mass displacement relative to standing) jump height [30]. Being acutely lighter would lead to increased jump height if the same or a greater net propulsive impulse was applied. This is because the take-off velocity that determines jump height is equal to the net propulsive impulse divided by body mass [16]. However, the jump height did not change post-match in the present study (Table 3), which supports previous studies involving the pre- and post-match CMJ testing of male soccer players [11,12]. This is because the jump momentum, which is equal in number to the propulsive net impulse [25], was significantly reduced post-match (Table 3). In effect, the reduced propulsive net impulse (the jump momentum in Table 3), when divided by the lighter body mass, led to the same 2.72 m·s⁻¹ take-off velocity (not shown in Table 3) and the 0.38 m jump height attainment post-match. The influence of body mass fluctuations on CMJ height following a

soccer match had not been explored previously, to the authors' knowledge. The present results, which showed an acute reduction in body mass, may partially explain why CMJ height has sometimes not been sensitive for detecting NMF induced by soccer match play within the scientific literature [11,12].

Previous reductions in body mass following soccer match play were attributed to water loss or glycogen depletion [17]. Specifically, fatigue towards the end of a soccer match has been suggested to be related to depleted glycogen stores within some muscle fibers [31]. Additionally, extended soccer match time (i.e., extra time) has been shown to further induce fatigue and the associated muscle glycogen depletion from $266 \pm 64 \text{ mmol}\cdot\text{kg}^{-1}$ dry weight after 90 min of match play to $186 \pm 56 \text{ mmol}\cdot\text{kg}^{-1}$ dry weight after an additional 30 min of match play [32]. This is noteworthy, given that depletion beyond $\sim 250 \text{ mmol}\cdot\text{kg}^{-1}$ is associated with reduced high-intensity exercise performance [33] and is specifically aligned with impaired exercise tolerance in elite soccer [34]. Although alterations in muscle glycogen stores post-match may be considered more of a metabolic than neuromuscular response, a recent study showed that through a principal component analysis, a force plate assessment of the CMJ can distinguish metabolic fatigue from NMF [35]; however, more research involving this approach is required. The total sweat rate was $2.04 \pm 0.57 \text{ L}$ during first 90 min of soccer match play in the study by Mohr et al. (2023), and the lead author's research group previously reported that many professional soccer players are typically hypo-hydrated [36]. The monitoring and coaching of hydration status and strategies, respectively, can improve hydration among professional soccer players [36]. Although the intake of carbohydrate–electrolyte gels improved blood glucose levels and soccer dribbling performance during an extra-time period of a simulated match, it did not attenuate reductions in hydration status or CMJ height [37]. Body mass was not significantly lower 12 h after a soccer match compared to the pre-match values in a study involving NCAA Division 1 female players [14]. However, body mass and CMJ measurements were, unfortunately, not recorded immediately post-match [14], so it is unknown whether the participants experienced a reduction in body mass immediately post-match, similar to the present study, which then returned to pre-match values by the 12 h time point due to the replenishment of water and glycogen stores.

Aside from the reduction in body mass, a shallower countermovement may have also contributed to the unchanged jump height post-match (Table 3). Previous studies have reported that a reduced countermovement depth leads to a reduction in CMJ height [38–40] by limiting the time and distance to generate a propulsive net impulse and work, respectively. Interestingly, the interactive effects of body mass and countermovement depth on the relationship between propulsive power output (propulsive work divided by time) and jump height in non-fatigued conditions were previously documented [41], but to the authors' knowledge, this is the first study to report acute alterations in each of these parameters due to competitive sports participation. In isolation, the countermovement depth was shown to be reduced immediately post-match [11] and on match day minus three [13] for male academy soccer players. Outside of soccer, the countermovement depth was shown to be the most sensitive CMJ variable when monitoring NMF across a full season in professional ice hockey [42]. Thus, the present findings suggest that reporting countermovement depth, along with body mass, jump momentum, or propulsive net impulse, alongside jump height, may be worthwhile when utilizing the CMJ to monitor acute NMF. Although not statistically significant, there was a small effect for the time to take-off (Table 3), which may suggest that a longer time is required to perform the CMJ despite a reduction in countermovement depth. While the current study was not able to prove this conclusively and only moderate pre-test reliability ($\text{ICC} = 0.67$) was noted, a previous cross-sectional study involving professional rugby league players (tested in a non-fatigued state) reported a very large correlation ($r = 0.719$, $p < 0.001$) between the time to take-off and countermovement depth [24]; thus, taking longer to perform the CMJ when performed with a shallower depth may be a potential subtle indicator of the presence of NMF and warrants further exploration.

To the authors' knowledge, this is the first study to capture CMJ performance data from a team within the National League, the fifth tier of English football. The match activity data were similar to those of elite players [43,44], as the players played, on average, 83 ± 11 min and covered just over 9.5 ± 1.9 km (Table 1). The sprint distances initially seemed slightly higher than previous records obtained from English Premier League matches (974 vs. 905 m, respectively) [44]. However, the current study's speed threshold was set by the GPS manufacturer at $>5.0 \text{ m}\cdot\text{s}^{-1}$, which was lower than the $>5.5 \text{ m}\cdot\text{s}^{-1}$ threshold in the aforementioned study [44]. No differentiation was made between discrete playing positions or markers of match volume or intensity that can be derived from GPS units to examine how these factors may have influenced the NMF markers gleaned from the CMJ data. This was due to the relatively small sample size, despite it being larger or equal to previous studies that have conducted pre–post force plate assessments of CMJ using sample sizes of nine [11], seventeen (split into a group of nine and a group of eight) [15], twelve [14], and fourteen [12]. The sample sizes in research involving football codes tend to be small due to often involving a single squad from a single club [45]. Nevertheless, future studies with larger sample sizes, potentially across multiple teams from the same league, may contemplate these considerations to help increase our understanding of how playing position and match demands might differentially affect NMF.

Because the CMJ is a variable multi-joint movement, it can be difficult to distinguish what has changed due to NMF from what is just the typical movement variability that is often observed in non-fatigued participants [46]. Reporting the force–time variables suggested previously alongside body mass when utilizing the CMJ to monitor NMF in soccer should be advantageous in practice compared with reporting jump height alone. However, there are further force-metric- and instrument-derived options available for consideration. For example, force sensors built within soccer boots have recently been validated for measuring GRFs during CMJs and on-field running, highlighting them as a potential future method of monitoring NMF during soccer match play [47], although further research into such devices is needed. Additionally, unlike the somewhat equivocal CMJ literature, recent studies have unanimously reported significant post-soccer-match peak force reductions [48–50] when utilizing isometric knee flexion tests on a force plate. Thus, soccer researchers and practitioners may wish to consider the CMJ metrics suggested in this study to provide more global insights into NMF, alongside a hamstring-specific peak force test, given the results of previous research [48–50].

5. Conclusions

This is the first study to report that reductions in body mass, and consequently body weight, and alterations to movement strategy (namely, countermovement depth) collectively explain the ability to maintain CMJ height values immediately following a competitive soccer match. The practical significance of these findings is that using CMJ height alone to objectively monitor acute NMF may be insufficient, despite the popularity of this approach in professional soccer clubs. As current soccer practitioners are more likely to use force plates to monitor their athletes' CMJ performances than they were in the past, it is recommended that they consider reporting countermovement depth, body mass (which can be derived from the force plate recordings of body weight), and jump momentum (or net propulsive impulse, as they are equivalent) alongside jump height. Collectively, these variables will help to explain why jump height changes or remains the same following soccer match play, thus providing valuable context when utilizing the CMJ as an indicator of acute NMF.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: All data (i.e., the mean and standard deviation of each metric) are shown in the tables referenced in the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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